[0022] Ti: up to 0.07%,

[0023] V: up to 0.3%,

[0024] B: up to 0.002%.

[0025] The Q&P steel is preferably a hot strip having a tensile strength (R_m) between 800 and 1500 MPa, a yield point (R_e) above 700 MPa, an elongation at break (A_{50}) between 7% and 25% to DIN EN ISO 6892, and very good deformability, for example a hole expansion of >20% to DIN ISO 16630.

[0026] Carbon (C) has several important functions in the Q&P steel. The C content primarily plays a crucial role in austenite formation during production, which is crucial particularly for the martensite in the end product. The strength of the martensite likewise depends strongly on the C content of the composition of the steel. In addition, the C content, by comparison with other alloy elements, makes the highest contribution to a higher CE value (CE=carbon equivalent), with an adverse effect on weldability. With the C content used, it is possible to specifically influence the strength level of the end product. Therefore, the C content is limited to between 0.1% and 0.3% in total.

[0027] Manganese (Mn) is an important element in respect of the hardenability of the Q&P steel. At the same time, Mn reduces the tendency to unwanted formation of pearlite during cooling. These properties enable the establishment of a suitable starting microstructure composed of martensite and residual austenite after the first quench (quench step) at cooling rates of <100 K/s. By contrast, too high an Mn content has an adverse effect on elongation and weldability, i.e. the CE value. Therefore, the Mn content is limited to between 1.5% and 3.0% by weight. To establish the desired strength properties, preference is given to using 1.9% to 2.7% by weight.

[0028] Silicon (Si) has a crucial share in the suppression of pearlite control and control of carbide formation. The formation of cementite binds carbon, and hence it is no longer available for further stabilization of the residual austenite. On the other hand, too high an Si content worsens elongation at break and surface quality through accelerated formation of red scale. A similar effect can also be achieved by the inclusion of Al in the alloy (>=0.5% by weight), such that, in combination with Al>=0.5% by weight, an Si content between 0.5% and 1.1% by weight is established. For the establishment of the features described above, a minimum of 0.7% by weight is required; preference is given to including contents over and above 1.0% by weight for reliable establishment of the desired microstructure. The upper limit is limited to a maximum of 1.8% by weight owing to the desired elongation at break, preferably to a maximum of 1.6% by weight for achievement of the desired surface quality.

[0029] Aluminum (Al) is used for deoxidation and for binding of any nitrogen present. Furthermore, Al can also, as already described, be used for suppression of cementite, but is not as effective as Si. At the same time, elevated addition of Al distinctly increases the austenitization temperature, for which reason cementite suppression is preferably implemented by Si only. To limit the austenitization temperature, an Al content of 0% to 0.003% by weight is established if sufficient Si is used for suppression of cementite. If, by contrast, the Si content, for example for reasons of the desired surface quality, is further limited, Al is included in the alloy with a minimum content of 0.5% by weight for cementite suppression. The maximum Al content of 1.5% by weight, preferably 1.3% by weight, results from the avoidance of casting-related problems.

[0030] Phosphorus (P) has an unfavorable effect on weldability and should therefore be limited to a maximum of 0.02% by weight.

[0031] Sulfur (S) in sufficiently high concentration leads to formation of MnS or (Mn, Fe)S, which has an adverse effect on elongation. Therefore, the S content is limited to a maximum of 0.003% by weight.

[0032] Nitrogen (N) leads to formation of nitrides, which have an adverse effect on formability. Therefore, the N content is limited to a maximum of 0.008% by weight.

[0033] Chromium (Cr) is an effective inhibitor of pearlite and can thus lower the required minimum cooling rate, for which reason it is optionally included in the alloy. For effective adjustment of this effect, a minimum proportion of 0.1% by weight, preferably 0.15% by weight, is envisaged. At the same time, strength is significantly increased by the addition of Cr, and there is additionally the risk of marked grain boundary oxidation. Furthermore, high Cr contents have an adverse effect on forming properties and on long-term strength under cyclical stress, which play a crucial role particularly in the case of wear-resistant, complex-shaped and cyclically stressed components. Therefore, the Cr content is limited to a maximum of 0.4% by weight, preferably 0.35% by weight, more preferably 0.3% by weight.

[0034] Molybdenum (Mo) is likewise a very effective element for suppression of pearlite formation. In the case of correspondingly defined analysis compositions, for reliable avoidance of pearlite, a minimum content of 0.05% by weight, preferably 0.1% by weight, is required. For reasons of cost, limitation to a maximum of 0.25% by weight is advisable.

[0035] Nickel (Ni), just like Cr, is an inhibitor of pearlite, but is not as effective. In the case of inclusion of Ni in the alloy, the corresponding minimum content is thus much higher than that of Cr and can therefore be 0.25% by weight, preferably 0.3% by weight. At the same time, Ni is a very costly alloy element and the addition of Ni significantly increases strength. Therefore, the Ni content is limited to a maximum of 1.0% by weight, preferably 0.5% by weight.

[0036] It is also possible to include microalloy elements (MLE) in the alloy, such as V, Ti or Nb, in the Q&P steel described here. These elements, through the formation of very finely distributed carbides (or carbonitrides in the case of simultaneous presence of N), can contribute to a higher strength. However, the mode of action of these three elements is very different. A minimal MLE content leads to freezing of the grain and phase boundaries after the hot rolling process during the partitioning step, which promotes the desired combination of properties of strength and formability by grain refining. The minimal MLE content for Ti is 0.02% by weight, that for Nb is 0.01% by weight, and that for V is 0.1% by weight. Too high a concentration of the MLEs leads to formation of carbides and hence to binding of carbon that is then no longer available for the stabilization of the residual austenite. In accordance with the mode of action of the individual elements, therefore, the upper limit for Ti is fixed at 0.07% by weight, that for Nb at 0.06% by weight, and that for V at 0.3% by weight.

[0037] Boron (B) is segregated at the phase boundaries and prevents their movement. This leads to a finer-grain microstructure, which can have an advantageous effect on the mechanical properties. Therefore, when this alloy ele-